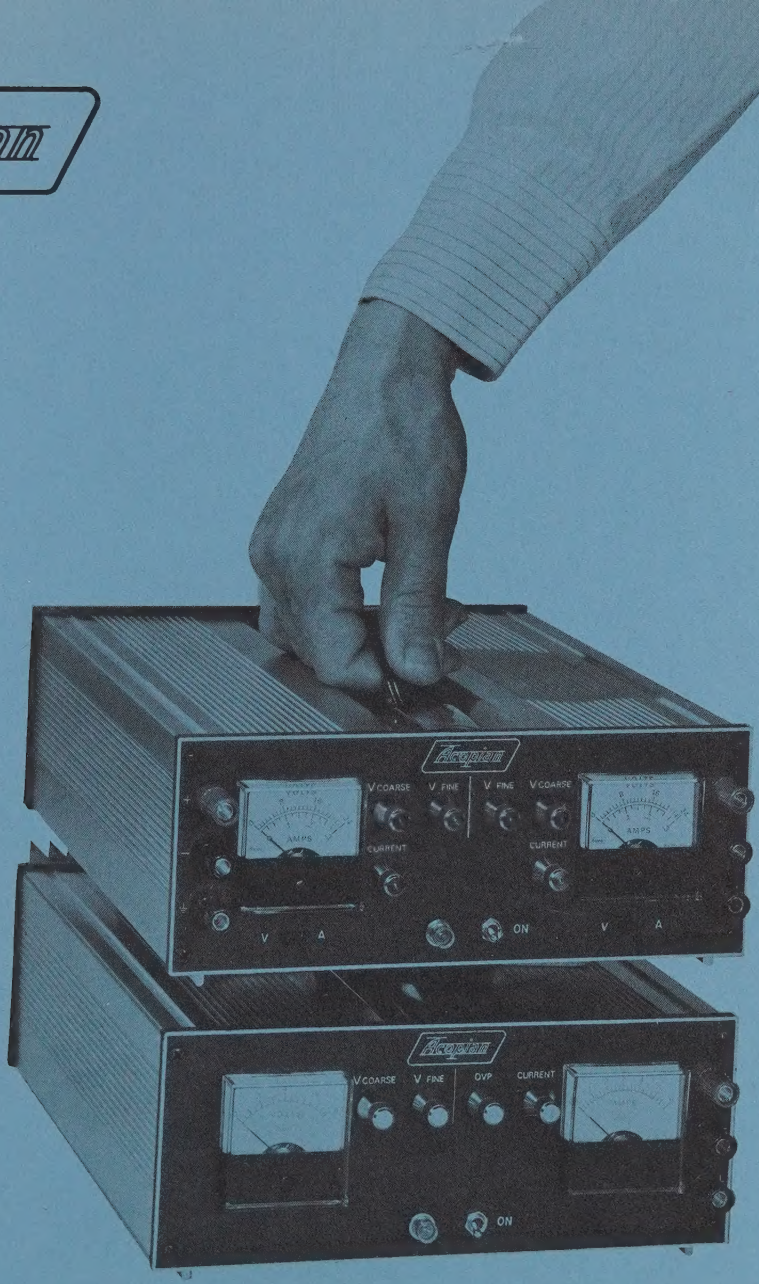
Acopian



OPERATING MANUAL

BENCHTOP POWER SUPPLIES

SERIES K

OPERATING MANUAL

BENCHTOP POWER SUPPLIES

SERIES K

All Series K benchtop power supplies were designed to provide the high performance, reliability, and versatility necessary in a laboratory instrument. A wide choice of single and multiple output models offer optimum combinations of the operating features and output ratings that are most often needed. They are also "human engineered" for convenience and ease of use. When more than one is required, they may be stacked to conserve bench space. Interlocking design prevents the upper units from slipping off.

Coarse and fine voltage controls permit setting outputs to a high degree of resolution, and adjustable current limiting prevents the load from drawing a higher current than intended. Many models provide constant voltage/constant current crossover, and may be used to deliver a regulated current to a varying impedance load. Some also include adjustable overvoltage protection.

Two meters provide for the simultaneous monitoring of voltage and current on single output supplies, or a combination of two output voltages or currents on dual and triple output models. The rugged casework is attractively finished in black and gold. "Five way" output binding posts and a retracting handle contribute to user convenience.

Acopian Corp. also manufactures an extensive line of modular and rack-mounting power supplies and multiple output assemblies designed to meet a variety of equipment and system requirements. Answers to your questions regarding any Acopian product, as well as assistance with your specific needs, can be furnished by an Acopian Applications Engineer. Call area code 215, 258-5441 or write to Acopian Corp., Easton, Pa. 18042.

SPECIFICATIONS

INPUT VOLTAGE

105-125 Vac, 50-400 Hz, single phase.

OUTPUT RATINGS AND PERFORMANCE

Vary with model number. See catalog.

OUTPUT ISOLATION

All outputs are isolated from case ground. Either positive or negative output binding post may be grounded or biased up to a maximum of 300 volts above case ground.

OUTPUT CURRENT CONTROL

Outputs specified as ACL are short circuit and overload protected by means of a continuously adjustable "rolloff" current limiting circuit.

Outputs specified as CV/CC deliver a constant voltage with increasing load until the current limiting point (continuously adjustable) is reached, beyond which voltage decreases as required to maintain a constant current. In addition to providing short circuit and overload protection, this feature permits the supply to be used as a current regulated power source.

STABILITY

Over an eight hour period, following a 30 minute warmup:

Constant voltage operation: 0.1%
Constant current operation: 15 ma.

TEMPERATURE COEFFICIENT

0.015%/°C.

TEMPERATURE RANGE

Operating: 0 to +50°C.
Storage: −40 to +85°C.

PROTECTION

Input: Line fuse.

Overload: Adjustable electronic current limiting with automatic recovery.

Overvoltage: "Crowbar" circuit, continuously adjustable down to 3 volts, protects load by effectively short circuiting output when "crowbar" trip point setting is exceeded. (Not included in all models. See catalog.)

TRANSIENT RESPONSE TIME

Less than 50 μsec, for a step change in input from 105 to 125 Vac, or in output current from no load to full rated output current.

OUTPUT IMPEDANCE (constant voltage operation)

Less than 0.03Ω from dc to 1 kHz.
Less than 0.5Ω from 1 kHz to 100 kHz.

METERS

Two, each accurate to 2% of full scale. On multiple output models, selector switches permit monitoring every output voltage and current.

CONTROLS

Power switch
Output voltage, coarse and fine adjustments
Output current limit
Overvoltage protection trip point (Not applicable to all models. See "Protection" above.)
Meter switches (multiple output models only)

CONSTRUCTION

Gold-finished extruded aluminum top and sides. Bottom, perforated aluminum panel. Front and rear panels, molded black phenolic. Retracting handle. Input power cord, 3-wire UL approved. Output connections, "five way" binding posts.

SIZE AND WEIGHT

Vary with model number. See catalog.

INSTALLATION

Series K power supplies are cooled by convection air currents. Sufficient space should be provided along their side and rear surfaces to permit unrestricted air flow.

To conserve bench space, two or more units may be stacked atop one another. Under this circumstance it is especially important that airflow around the sides and rear is not blocked. Excessive heat buildup will adversely affect both stability and reliability.

Never use a fuse with a rating other than that stamped on the rear of the power supply. Use a slow-blow type fuse. Fast acting fuses tend to be blown by the current surge normally drawn by a power supply at turnon.

OPERATION

The instructions below apply to single output models, to each output of dual output models, and to the independent output of triple output models. The balanced (plus and minus) output voltages of triple output models track (i.e., they are both adjusted simultaneously with a single set of controls), and their current limit points are fixed. Note that the output voltage ranges and current ratings are shown on each meter scale with a solid arc.

If there is any possibility of voltage from another source (another power supply, a battery, transients, etc.) being applied to the power supply's output terminals, protect the power supply by using a diode in series with the output leads. Never use a fuse with a rating greater than specified on the rear panel.

Do not attempt to parallel the outputs of two power supplies, or both outputs of dual models. This would result in current flowing from the higher-set output into the lower-set output, and probable damage to both circuits. Outputs may be connected in series; however, keep in mind that the output current intended to be drawn cannot be greater than the output current rating of the lowest rated supply used.

Keep the current limit control (and overvoltage protection control, when applicable) set fully clockwise, except when output limiting is desired.

For constant voltage operation, turn on the power supply and adjust the output voltage controls to the desired output voltage. If it is desired to limit the output current to a specific amplitude, turn the current control fully counterclockwise, then short circuit the output terminals and advance the output current control. Set the current at least 10% higher than the output current which will be drawn by the load, to avoid operation in the knee area of the current limit characteristic curve. (If the impedance of the load should decrease to less than that which would draw the set current at the voltage setting, the output voltage will automatically drop to the point at which the set output current is drawn.) Finally, turn off the supply, remove the short circuit, and connect the load.

In setting the current limit point, allowance must be made for the highest peak current which the load may attempt to draw in normal operation; otherwise, undesired limiting will occur and may result in improper operation of the load. An internal capacitor across the output terminals will tend to supply higher current pulses of short duraction, and additional capacitance may be added externally if desired. However, this will reduce the effectiveness of the current limit circuit and increase the risk of an unintended surge current damaging sensitive components in the load, particularly semiconductors with a short thermal time constant.

To set the overvoltage protection trip voltage of models having that feature, start by turning the output current and overvoltage controls fully clockwise, and the output voltage controls fully counterclockwise. Adjust the output voltage to the desired overvoltage protection trip voltage (which should be at least 10% higher than the desired operating voltage), then slowly turn the overvoltage protection control counterclockwise until the output voltage collapses. Turn the output voltage control fully counterclockwise; this will unlatch the overvoltage protection circuit. Readjust voltage to the desired operating level. Short circuit the output and set the current control to the desired current limit level. When the power supply is in use, the overvoltage protection circuit will trip whenever the output voltage rises to the trip voltage (even if only

instantaneously, as can occur if a load transient feeds back into the power supply), and will remain latched until the output voltage is interrupted. It can be reset without changing the control settings simply by switching the power supply off momentarily. If overvoltage protection is not desired, set the control to its fully clockwise position.

For constant current operation, set the voltage and overvoltage protection controls fully clockwise, short the output terminals, turn on the power supply, and adjust the current control to the desired output current. Remove the short. If it is desired to limit the compliance voltage to less than the maximum output voltage of the supply, reduce the voltage to that level. Turn off the supply, and connect the load.

If multiple loads are to be connected to one power supply output, each should have a separate pair of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If shielded wire is used, connect the shields to the power supply ground terminal only, and leave them unconnected at the load end. Otherwise, ground currents in the shields could reduce their effectiveness.)

PRINCIPLES OF OPERATION

GENERAL

The circuitry of each Series K power supply consists of an ac input transformer; a main regulator circuit consisting of rectifiers, filter capacitor, and series regulator transistor(s); a voltage control circuit consisting of a voltage error sensing amplifier and the current amplifier (emitter follower) stages which drive the series regulator; a current control circuit; and an auxiliary supply consisting of rectifiers, capacitive filters, and constant current amplifier(s) to power the control circuits.

The circuit diagrams included in this manual apply to the entire series of power supplies. Multiple output models contain two or more complete circuits, but share one transformer having multiple sets of secondary windings. On these models, the meters are switched rather than hard wired as shown, to permit the monitoring of all outputs.

FUNCTIONAL DESCRIPTION

Refer to the pertinent schematic diagram (Figure 1 for power supplies with adjustable current limiting, Figure 2 for supplies with constant voltage/constant current crossover.) The former provides a limiting characteristic adequate for overload or short circuit protection, but does not regulate in the current mode as precisely as the latter.

On all models, 105-125 Vac single phase input power is applied to the primary winding of power transformer T_1 via the input power cord. The main secondary winding provides the power which is rectified by the diode bridge consisting of K_1-K_4; filtered by capacitor C_5; regulated by series pass transistor(s) Q_1; and delivered through current sensing resistor R_{13} to the output terminals.

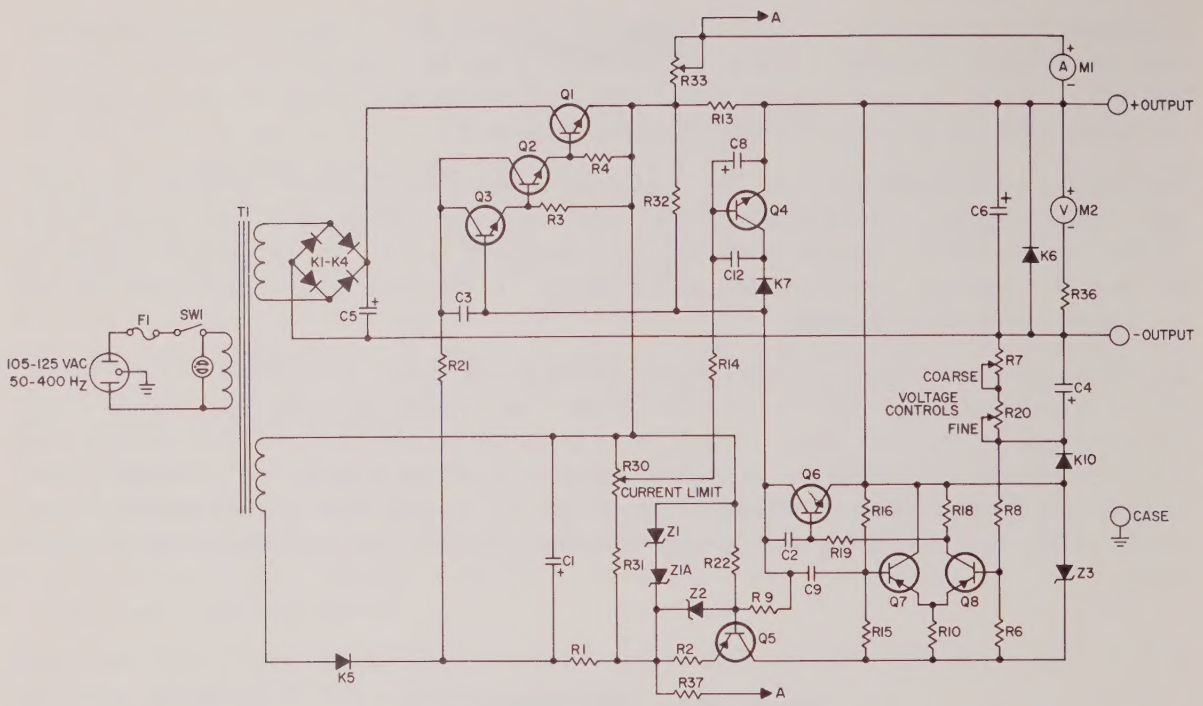


FIGURE 1. SCHEMATIC DIAGRAM, SERIES K POWER SUPPLIES WITH ADJUSTABLE CURRENT LIMITING.

The voltage control portion of the control circuit is also the same on all models. Q_5 provides Zener diode Z_3 and differential error detection amplifier Q_7-Q_8 with a current which remains essentially constant regardless of variation in the input voltage applied to the power supply, and independent of power supply output loading. The voltage applied to the base of Q_7 is a function of the voltage across Z_3 and thus remains constant. The voltage at the base of Q_8 is proportionate to the current flowing through R_6, and will be affected by any change in the output voltage. Any change is inverted in polarity and amplified by driver Q_6 and current amplifiers Q_2-Q_3 (and Q_4, where used), tending to change the output voltage as required to restore the voltage at the base of Q_8 to its initial level and resulting in a regulated output.

Additionally, this circuit characteristic is utilized as the means to adjust the output voltage of the supply. Varying the division ratio of the voltage divider consisting of R_6, R_8, and the output voltage controls, will result in changing the output voltage as required to maintain the equilibrium voltage at the base of Q_8.

ADJUSTABLE CURRENT LIMITING

The current control circuit used in models specified as having adjustable current limiting, and the auxiliary supply to which it is referenced (and which also powers current amplifiers Q_2-Q_3 and the voltage control circuit), are shown in Figure 1. The voltage from the second transformer secondary winding is rectified by diode K_5; filtered by capacitor C_1; preregulated by Zener diode Z_1 and current limit resistor R_1; and the output of the current regulator consisting of Q_5, Z_2, R_2, and R_{22} powers the voltage control circuit.

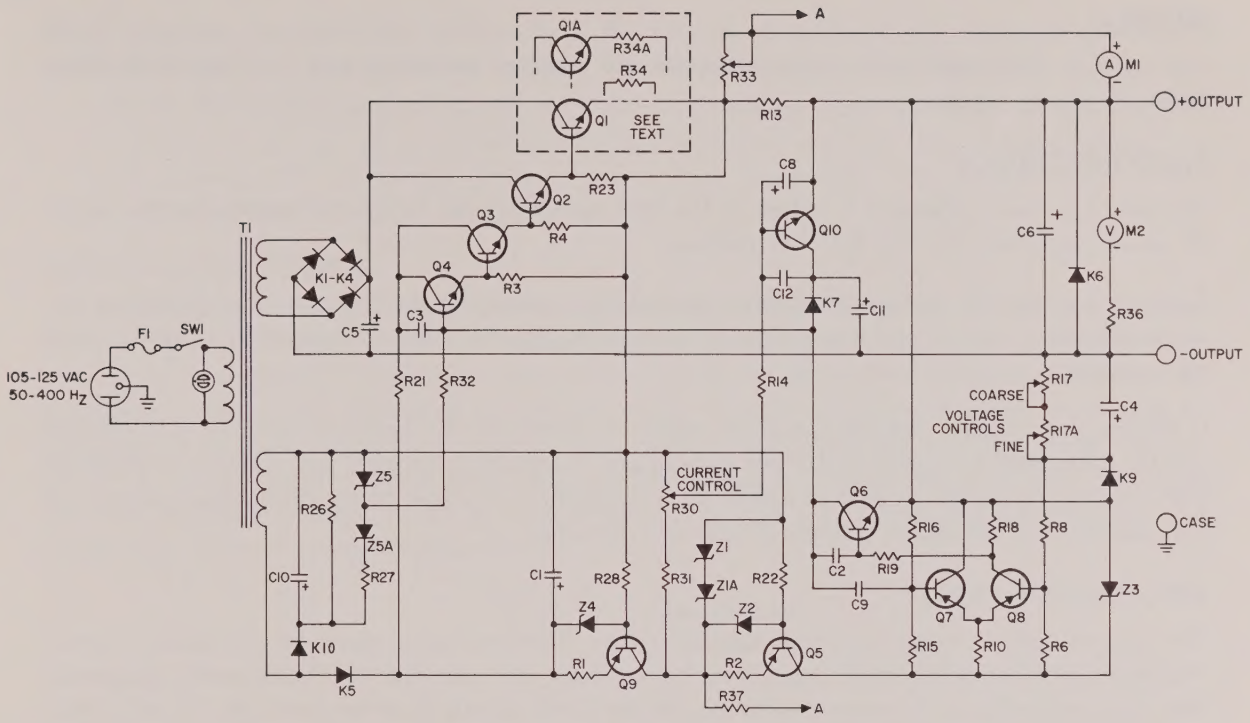


FIGURE 2. SCHEMATIC DIAGRAM, SERIES K POWER SUPPLIES WITH CONSTANT VOLTAGE/CONSTANT CURRENT OUTPUT CROSSOVER.

Current limit transistor Q_4 and associated components sense the output current, as a function of the voltage drop across R_{13}. The voltage applied between the base of Q_4 and the high end of R_{13} is determined by the setting of current limit control R_{30}. When the drop across R_{13} does not exceed that voltage by enough to support conduction in the emitter lead of Q_4, which is connected to the low end of R_{13}, the circuit is biased OFF and limiting does not occur. However, if the drop across R_{13} increases sufficiently to support conduction in the emitter-base junction of Q_4, the transistor conducts, increasing the current flow through R_9, and the voltage drop across it. This reduces the voltage at the base of Q_3, and in turn, the output voltage of the power supply. The output voltage is reduced to the voltage at which the load draws the set current.

CV/CC CROSSOVER

The current control and auxiliary supply circuits used in models specified as having constant voltage/constant current crossover are shown in Figure 2. Their principles of operation are essentially the same as described above; however, more precise control of the bias voltage on the base of the current control transistor (Q_{10}) is obtained by using a current regulator (Q_9) to drive the Zener diodes (Z_1 and Z_{1A}) which regulate the voltage across current control R_{30}. Also, due to the higher output current ratings of these models, an additional current amplifier (Q_4) is used with Q_2 and Q_3 to drive output stage Q_1. The highest output models utilize two paralleled transistors, with current splitting resistors R_{34} and R_{34A}, as the output stage.

MAINTENANCE

GENERAL

This section describes recommended routines for testing, servicing, and calibrating Acopian Series K power supplies.

FACTORY SERVICE

Acopian maintains extensive facilities at the factory, staffed by trained personnel, for the repair of power supplies returned for that purpose.

Contact Acopian for authorization prior to making a return shipment; unexpected shipments are more difficult to trace and more time is required to process them. Transportation charges must be prepaid.

If the required repairs are not covered under the terms of the Acopian warranty, a quotation will be submitted for approval before repairs are completed. Repairs are normally completed within three days after receipt of goods (if in warranty) or within three days after receipt of authorization to bill repair charges (if out of warranty).

REPLACEMENT PARTS

The designs used in Acopian power supplies utilize standard components to the greatest practical extent. When transistors, capacitors, or resistors are required for replacement purposes, the types originally used or equivalents can be obtained quickly and economically from a local electronic components distributor.

Special components, such as transformers, are stocked in depth at Acopian. Write or telephone for information on the parts required, referencing the model number of the power supply, the circuit designation of the part, and a description. Parts are normally shipped within 24 hours after receipt of order.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check for external causes first, including all fuses, primary power lines, external circuit elements, and external wiring. Failures and malfunctions often can be traced to simple causes such as improper wiring or connections.

Inability to obtain a desired output voltage within the rating of the power supply is most often caused by current or overvoltage controls set too low. See page 4.

Use the schematic diagrams, Figures 1 and 2, as aids in locating trouble causes. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an in-circuit transistor checker. If no checker is available, transistors can be checked with an ohmmeter that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional faulty components, could damage the replaced component.

When soldering semiconductor devices, hold the lead being soldered with a pair of pliers or a commercial heat sink device placed between the component and the solder joint.

NOTE: The resistance reading obtained with a simple in-circuit resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PERFORMANCE TESTING

The performance of a regulated power supply is determined primarily by the internal (source) impedance of the supply, which the intended load sees in series with it and the voltage at which the supply is operating. Since the instantaneous voltage at the load is therefore equal to the operating voltage minus the drop across the source impedance, a power supply must have an extremely small source impedance in order to provide a well regulated output voltage. For example, a 12 volt supply with $\pm.01\%$ load regulation and a current rating of 100 ma would exhibit a maximum voltage variance of $12 \times 10^{4} \times 2 = 2.4 \times 10^{-3}$ volts, or 2.4 millivolts, and would have a static source impedance of

$$\frac{2.4 \times 10^{-3}}{10^{-1}} = 24 \text{ milliohms.}$$

Obviously, to accurately measure voltages and resistances of these orders of magnitude requires the use of a test setup that will not introduce additional unintended impedance between the voltage source and the point at which the voltage is observed. No load current can be permitted to flow through the measurement leads, and they must be connected directly to the output terminals. Connections must be clean and tight.

MEASUREMENT OF REGULATION

Accurately measuring a voltage change of less than one percent requires either the use of a high resolution digital voltmeter or the application of differential measuring techniques. The latter is most easily accomplished by placing a stable and adjustable voltage source in series (but opposite in connection polarity) with an analog voltmeter or millivoltmeter (VOM or VTVM), or a high sensitivity dc-coupled oscilloscope, and with the voltage being measured. The adjustable voltage can then be set to "buck-out" or cancel the voltage being tested, at a given operating point of the supply, so that the voltmeter will then indicate not the absolute voltage, but the change in voltage resulting from a change in operating conditions.

TEST FOR LINE REGULATION

The supply under test must be furnished with an accurately metered and adjustable source of line voltage that is capable of handling the full load primary current. The use of an adjustable autotransformer is recommended. An accurately metered resistive output load capable of being adjusted to draw the full rated load current is also required. Observe change in output voltage as discussed above.

1. Set input voltage to 115Vac, 50 to 400Hz. Set output voltage at high end of range (end of arc marked on voltmeter) and set load to draw full rated current. Current control(s) must be set fully clockwise. Null output voltmeter if differential measurement technique is being used.
2. Vary input voltage from 105 to 125 volts while observing output voltage change and noting maximum deviation from the output obtained with 115Vac input.

3. Line regulation performance is within specifications if the maximum change in output voltage is equal to, or less than,

$$\frac{\text{DC output voltage x line regulation specification in percent}}{100}$$

TEST FOR LOAD REGULATION

The supply under test must be furnished with a stable source of 115Vac, 50 to 400 Hz. A resistive output load capable of being adjusted to draw either half or the full rated load current is also required. Observe change in output voltage as discussed above.

1. Set current control(s) fully clockwise. Adjust load so that half the rated current is being drawn from the supply at the maximum rated output voltage. Null output voltmeter if differential measurement technique is being used, or note reading of digital voltmeter.

2. Remove load and note change in output voltage, then adjust load to draw the full rated current and again note the change from the nominal voltage. The larger change represents the load regulation.

Thus, if $\text{larger voltage change} < \frac{\pm\%\text{ load regulation specification x Nominal output voltage}}{100}$

the supply is within its load regulation specification.

TEST FOR AC RIPPLE AND NOISE

The 2.8/1 peak-to-peak/rms voltage ratio is not completely valid in determining the rms ripple of a power supply by observation of the peak-to-peak amplitude, because the waveform typically is not sinusoidal. However, for all but the most exacting applications, division of the peak-to-peak amplitude by a factor of three will determine the rms amplitude with a practical degree of accuracy.

An ac millivoltmeter may be used for reading ripple, but an ac coupled oscilloscope is generally more practical. The supply under test should be loaded to deliver its full current rating while ripple amplitude is being read.

MEASUREMENT OF SOURCE IMPEDANCE

The ac internal impedance of a regulated power supply is a function of frequency and, in general, increases with frequency. The impedance at a given frequency can be most easily determined by driving a known ac current of approximately 10 ma. rms (the voltage drop across an external resistor can be used to calculate current. $I_{p\text{-}p} = E_{p\text{-}p}/R$) through the output terminals of the power supply, and measuring the ac voltage drop across them. Source impedance $= E_{p\text{-}p}/_{p\text{-}p}$. Since the supply must be operating to perform this measurement, a capacitor must be used in series with the supply and the signal generator, to prevent application of the dc voltage to the generator. In making this measurement, care must be taken to minimize lead lengths and to prevent ground loops, since these factors can greatly affect the accuracy of test results.

	Models in Case Sizes K9, DK9, and DK10	Models in Case Sizes K10 and K11
R1	180 ohm 2W 10%	91 ohm 1W 5%
R2	220 ohm ½W 10%	220 ohm ½W 10%
R3	1K ½W 10%	2.2K ½W 10%
R4	220 ohm ½W 10%	220 ohm ½W 10%
R6		
R7		
R8	150 ohm ¼W 5% (metal film)	150 ohm ¼W 5% (metal film)
R9		
R10	680 ohm ¼W 5% (metal film)	680 ohm ¼W 5% (metal film)
R13		
R14	3.3K ½W 10%	3.3K ½W 10%
R15	680 ohm ¼W 5% (metal film)	680 ohm ¼W 5% (metal film)
R16	390 ohm ¼W 5% (metal film)	390 ohm ¼W 5% (metal film)
R17		
R18	390 ohm ¼W 5% (metal film)	390 ohm ¼W 5% (metal film)
R19	470 ohm ¼W 10%	
R20		
R21	510 ohm ½W 10%	1K ½W 10%
R22	4.7K ¼W 10%	560 ohm ¼W 10%
R23		56 ohm ½W 10%
R26		5.6K ¼W 10%
R27		2.2K ½W 10%
R28		4.7K ½W 10%
R30	150 ohm potentiometer	150 ohm potentiometer
R31	2.2K ½W 10%	2.2K ½W 10%
R32	3.3K ½W 10%	6.8K ½W 10%
R33		
R34		
R36		
R37		
C1	220 μfd/35V	680 μfd/40V
C2	.01 μfd/50V	.01 μfd/50V
C3	.01 μfd/50V	.01 μfd/50V
C4	22 μfd/63V (typical)	10 μfd/63V
C5		
C6	220 μfd/40V (typical)	
C8	.68 μfd/63V (typical)	.68 μfd/63V
C9	.002 μfd/50V	.002 μfd/50V
C10		10 μfd/63V
C11		2.2 μfd/63V
C12	.01 μfd/50V	.01 μfd/50V
Q1	2N3055 or MJE-3055 (Motorola)	2N3055
Q2	2N3053	MJE-3055 (Motorola)
Q3	2N3053	2N3053
Q4	2N3565	2N3053
Q5	2N2907A	2N2907A
Q6	2N3568	2N3568
Q7	2N2907A	2N2907A
Q8	2N2907A	2N2907A
Q9		2N4037
Q10		2N3565
K1-K5	1N4002	1N4002
K6	1N4002	1N4002
K7-K10	1N4002	1N4002
Z1	1N755	1N755
Z2-Z5A	6.2V @ 1.5 ma 400 mw	6.2V @ 1.5 ma 400 mw
M1,M2	0-1 ma dc. Scale varies with power supply model number.	0-1 ma dc. Scale varies with power supply model number.

NOTE: Component values not shown vary with model number. Contact factory for the value(s) applicable to a specific model.

This parts list is intended to be a guide for replacement purposes only and does not necessarily indicate the exact parts used by Acopian for the production of the power supply.

Acopian reserves the right to make changes or improvements upon its products without imposing any obligation relative to units previously manufactured.

BASIC PARTS LIST, SERIES K POWER SUPPLIES

WARRANTY

The Acopian products described in this manual are covered by a firm five-year warranty which includes the cost of both parts and labor. The warranty is honored at the factory Service Department in Easton, Pa. If the failure has been caused by misuse, operation in excess of specifications, or modifications by the customer, repairs will be billed at cost; in such cases, a cost estimate will be submitted before work is started.

Power supplies returned to the factory for repair must have shipping charges prepaid and must be accompanied by documentation explaining the reason for the return. Written authorization must be obtained from Acopian prior to returning any goods for warranty examination.

Acopian reserves the right to make changes or improvements in its products without incurring any obligation with respect to products previously manufactured.

This warranty is in lieu of all other obligations, expressed or implied.

www.manualsplus.com
1020048

ACOPIAN CORP., EASTON, PENNSYLVANIA 18042

TELEPHONE: (215) 258-5441